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A robot device for measurement of angular distributions with high energy resolution

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With 4 figures in the text

Introduction

Information on spin and parities of nuclear states is obtained by studying the angular distributions of secondary particles from nuclear transmutations.

Measurement of angular distributions from nuclear reactions is easiest performed by means of photographic plates placed around the target. Generally many particle groups occur simultaneously during bombardment which have to be distinguished from each other by reading the length of the tracks in the microscope. This is always possible when the energy differences between the particle group energies are large. When the particle groups are very close in energy, however, the discrimination of the tracks becomes very difficult or impossible.

For these cases—and there are many important such cases—a magnetic analysis of the particle momenta is necessary. This means that a magnetic spectrometer mounted on a rotating tables is required. Very convenient for this purpose is the double focusing spectrometer with large solid angle at the Nobel Institute [1]. This instrument is rotatable to a very high degree of mechanical precision around a vertical line through the center of the target surface.

The monitoring problem

The monitoring problem is closely related to the degree of accuracy ultimately required in the angular distribution.

To be able to interpret the distributions one really needs an accuracy of a few percents in the values of the relative intensities. This outrules many simple methods of monitoring.

The monitoring is the method by which one obtains the relative intensities at different angles referred to the number of bombarding particles per second and the number of target nuclei hit by the beam. These are the values that should be known with high relative accuracy. Under actual running conditions the number of target nuclei within the beam area may change with time: for instance, a few percent of the target nuclei may be shot away by the bombarding beam or the target may not be uniformly thick and the beam intensity may vary within the beam area. Also the beam current may vary with time.

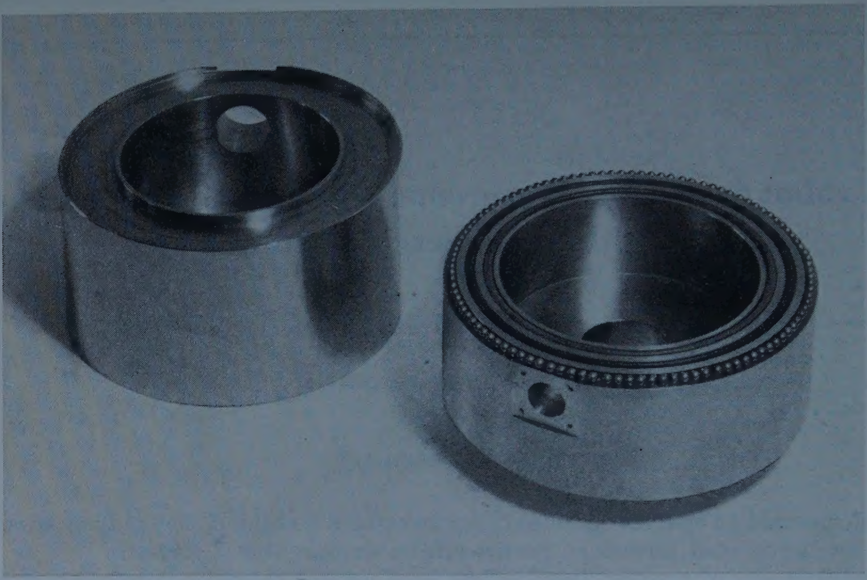

Fig. 1. Picture of lower and upper parts of stainless steel chamber. (Lower part right, upper part left.)

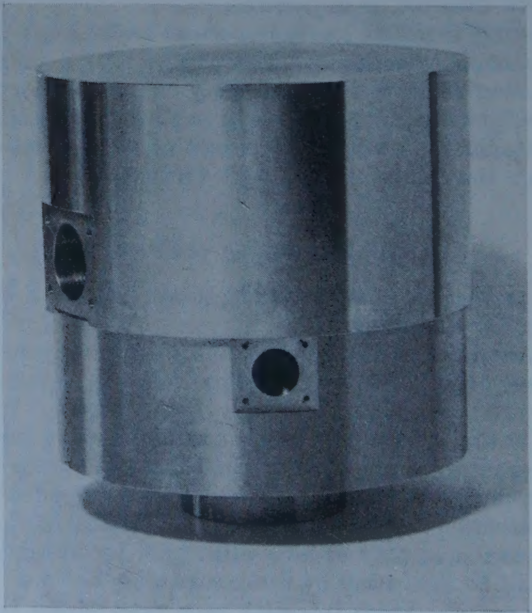

Fig. 2. Total view of target chamber.

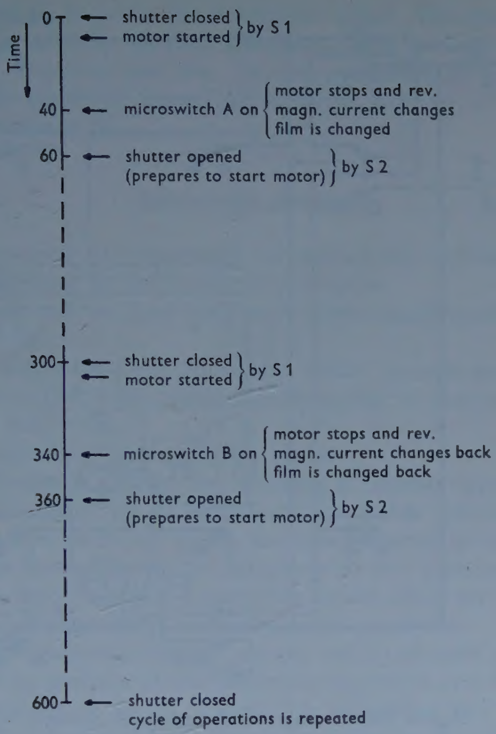

Fig. 3. Cycle of operation of automatic device.

All these variations have to be controlled or measured during the experiment. This can be done by placing a photographic plate at a reference angle for each measurement with the spectrometer. In this way one gets for each angle two values which are integrated over time, one in the photographic plate of the spectrometer and one in the reference plate. The reference plate would be reached by a very large number of particles both scattered particles and particles from unavoidable parasite reactions on oxygen, nitrogen and so on. This, actually, makes it hardly realistic to try to monitor the angular distribution of a weak particle group with a simple reference plate. The ideal arrangement would be to analyze magnetically also the particles that go to the reference plate. A special magnet for the reference plate would have to be nearly as big as the spectrometer itself and would not be a practical solution of the problem.

Therefore, the spectrometer is used also for the reference measurement. During an accurately known length of time the spectrometer receives the particles at the angle of measurement θ (θ is the angle between bombarding direction and the measuring direction of secondary particles). Then it is turned and during a similar length of time it takes the particles at a reference angle θ_r, then it goes back to θ and so it is turned back and forth a number of times. With this monitoring method the effects of slow changes on the distribution, for instance a change in target composition, are cancelled and other changes can be detected.

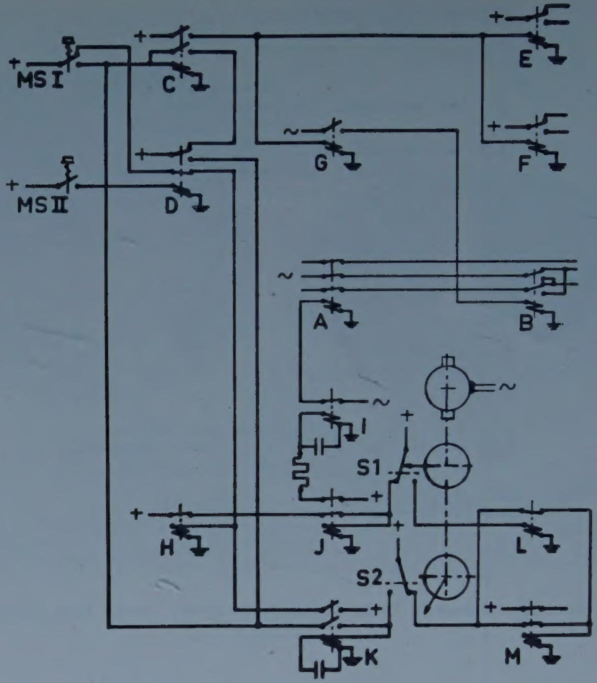

Fig. 4. Circuit diagram of automatic device.

The target chamber

As the spectrometer has to be turned so often it is necessary to have a vacuum chamber for the target that allows the spectrometer to be turned without requiring the vacuum system to be opened. The desired region of θ is from about zero to 135°. It is not possible to achieve this with bellows keeping the path free for the bombarding beam and the secondary beam.

The construction adopted here is shown in Figs. 1 and 2. The chamber consists of a lower and an upper half. The bombarding beam enters in the lower half and the secondary beam leaves through an opening in the upper half. The tightening is achieved with two rubber gaskets.

The atmospheric pressure keeps the two halves together with a force of 100 kg. If this force were taken up by the rubber gaskets alone it would be very difficult to turn the halves relative to each other. To facilitate the rotation of the upper part of the chamber there is a groove in the lower part for a number of small steel balls, as shown in Fig. 1. The dimensions of the groove and the balls are chosen such that the upper part of the chamber is carried at a height which corresponds to convenient compression of the rubber gaskets. In this way the upper half can be rotated without much effort.

The mounting is such that top and bottom of the chamber are parallel to the horizontal plane. The bombarding beam will enter the chamber at a slightly upward direction forming a small angle to the horizontal plane. The secondary beam leaves the chamber also at a slightly upward direction. This is required not only by the construction of the chamber but also by the properties of the spectrometer [2]. All the details of the eccentric mounting of target support, of angle measurement etc. are described elsewhere [3].

Automatic devices

The following operations are necessary for measuring angular distributions with the spectrometer according to the outlined principles:

1. Turning the spectrometer from a present, chosen angle position to the reference position and vice versa.
2. Changing the magnetic field from the value corresponding to the particle energy at the chosen angle to the value corresponding to the particle energy at the reference angle and vice versa.
3. Changing the detecting photographic plate.
4. Opening and closing a shutter for defining a precise exposure time.

The spectrometer is turned by an electric motor which operates on the periphery of the large circular iron table on which the spectrometer is mounted. Two microswitches which can be moved along the periphery to any position will stop the motor when the table comes into the desired position. As the diameter of the table is about two meters one will get repeatedly accurate angle positions.

The changing of the magnetic field is simply achieved with a relay that chooses between two alternative settings of the electronic regulator and between two settings of the precision compensator which is used for measuring the field.

The changing of the photographic plate is intended to be obtained later on with a mechanical device.

The exposure time is determined by contactors on a circular disc driven by a synchronous motor. The contactors connect a relay which is intended to operate a commercial shutter from an ordinary camera placed between the target and the spectrometer. The exposure time will be 300 sec.

One sixth of the periphery of the timing disc is reserved for the time period when the spectrometer is turned and the changing of magnetic field and photographic plate takes place. The whole cycle of operations is represented in Fig. 3. The circuit diagram of the device is shown in Fig. 4.

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